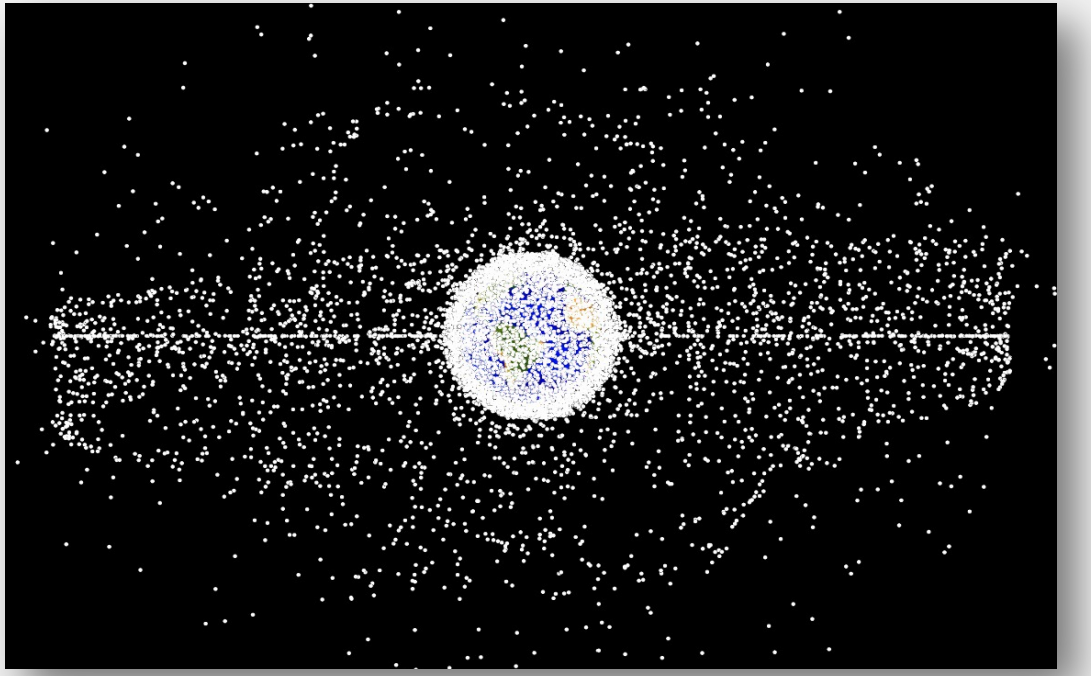
The Fragile Frontier

Charting Global Space Traffic Management Solutions

Space is becoming extraordinarily congested.

This NASA-generated image represents the **object population** in the near-Earth environment.

There are no internationally accepted standards or distancing guidelines that define **how close is "too close."**

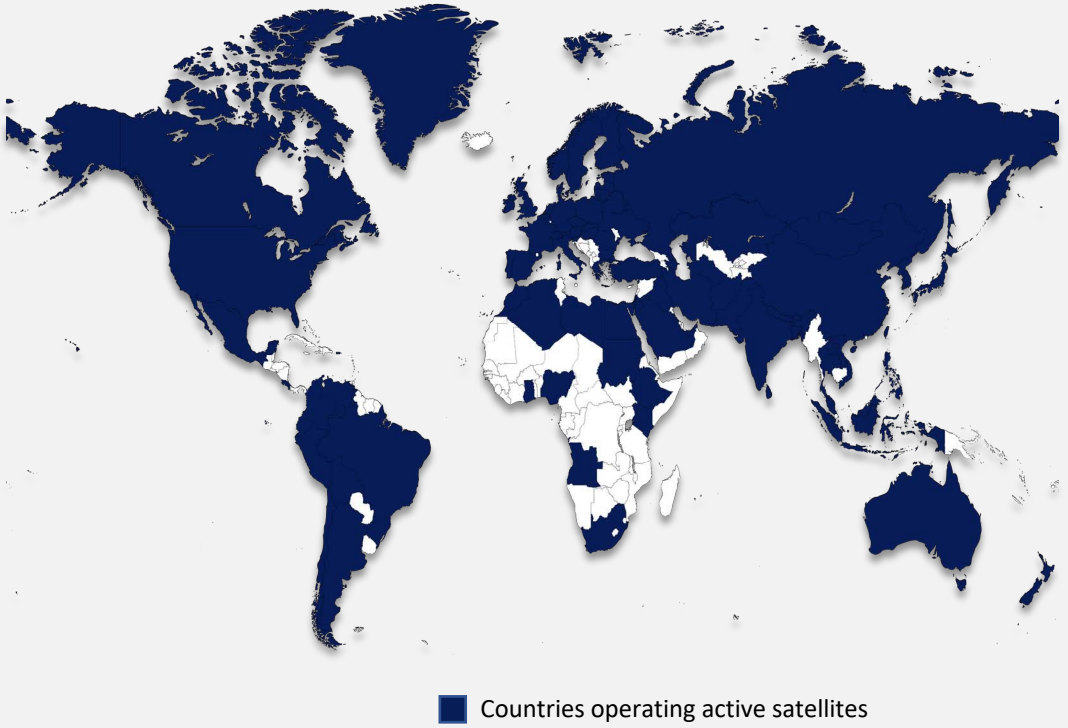


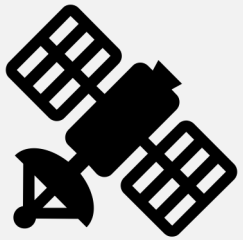
SOURCE: NASA Orbital Debris Program Office.

No real rules of the road exist for spacecraft.

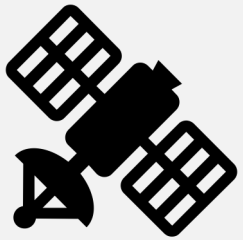
This map shows entities from **more than 80 different countries** operating active satellites in orbit.

No nations have adopted comprehensive and enforceable space traffic standards, and **no common space traffic approach exists** between nations.





How might an effective **international space traffic management** (STM) system be realized?

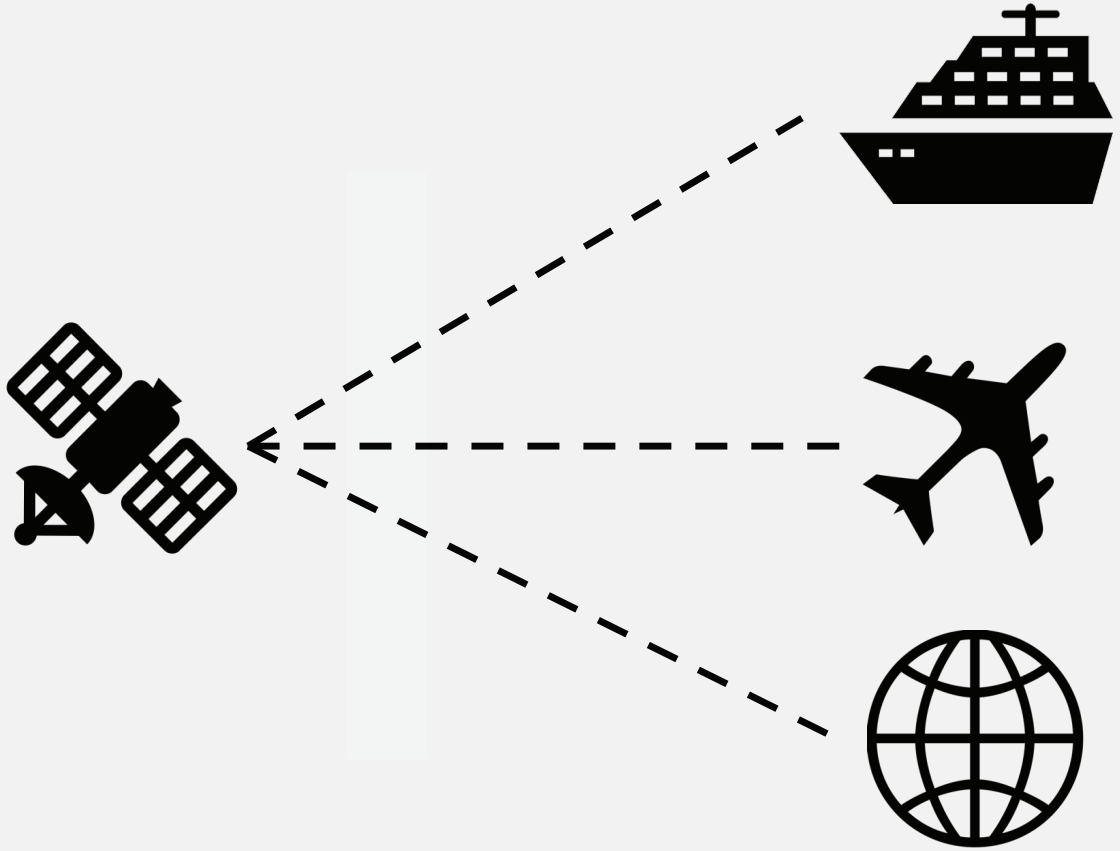


Bottom-Up

Flexible but Fragmented

Top-Down

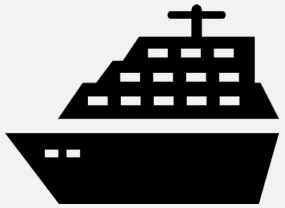
Resolute but Rigid



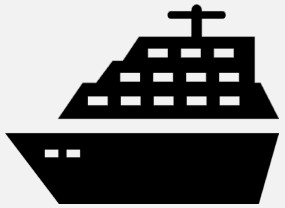
Maritime Domain Lessons

Air Domain Lessons

Global Governance Lessons



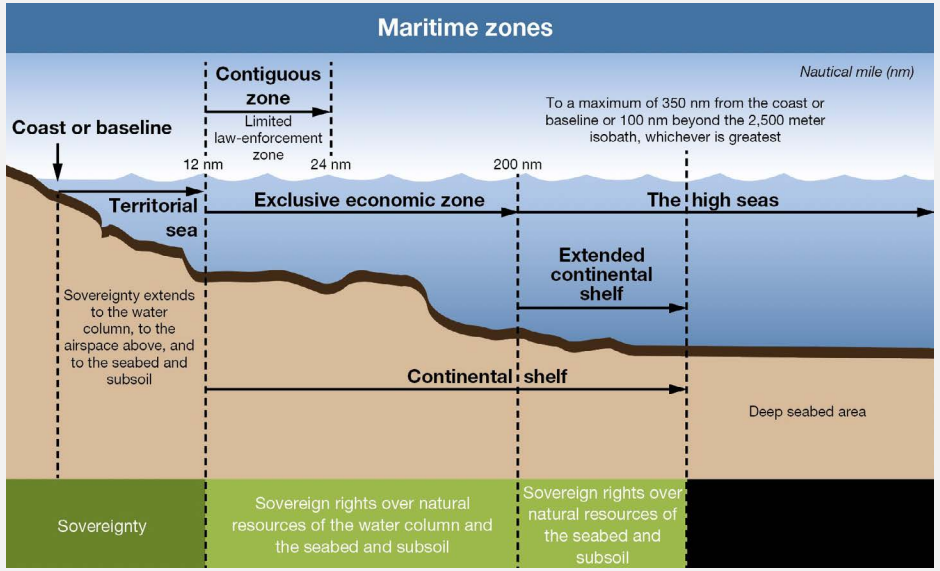
What can be learned from the **maritime domain**?



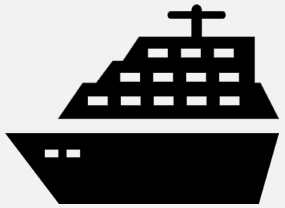
Centuries of **gradual norm development** eased transition to global system

Early **governance failures** fueled state and industry pressure for improvement

Current system supported by **clear territory delineation**, weakest in the high seas



SOURCE: Adapted from Margaret Bohan, "NOAA's Participation in the U.S. Extended Continental Shelf Project," National Oceanic and Atmospheric Administration Office of Ocean Exploration and Research, undated.



Governance enabled by **widespread, UN-backed** governance structures (International Maritime Organization [IMO] and UN Convention on the Law of the Sea [UNCLOS])

Representation of **various interests** (funding and organizational structure) cultivates legitimacy

High **technical expertise** at international level facilitates sound rulemaking

What can be learned from the **air domain**?

Shorter timeline from first flight to international governance organization (International Civil Aviation Organization [ICAO]) than in maritime domain

Bottom-up commercial pressure catalyzed **domestic regimes, harmonized** via UN Convention

Governance improved through and in response to **technological advancements**

ICAO evolution proves **industry, or bottom-up demand,** can motivate global traffic norms development

Flexible regulatory structure (variances) facilitates widespread adoption of central standards

Interoperability and global acceptance of key aviation **technologies** remain critical to ICAO effectiveness

What can be learned from **global governance** in other technical areas and as a whole?

The **International Telecommunication Union (ITU):** democratic organizational procedures and private participation and financing

Internet Corporation for Assigned Names and Numbers (ICANN): institutional flexibility and the transition toward more multipolar governance

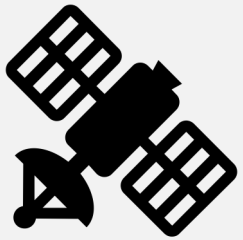
Society for Worldwide Interbank Financial Telecommunication (SWIFT): technical integration and the formative role that private actors could play

Broad international governance research underscores **legitimacy** as key to effectiveness and longevity

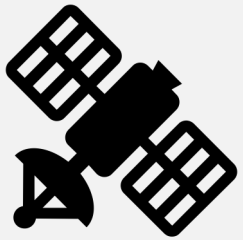
Regional, democratic organizations that emphasize **technical** cooperation enjoy higher legitimacy

A **large, well-funded** bureaucratic staff is consistently the biggest predictor of intergovernmental organization success

Major issue is in cooperation with **Russia and China**



What are **key insights and recommendations** for international space traffic management?

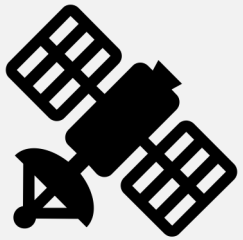


Key Takeaways

A bottom-up approach is **already underway** for STM, but we are approaching a **tipping point.**

Institutional legitimacy is needed for the effectiveness and endurance of an STM regime.

A viable global STM governance system will require **expertise and funding.**



Recommendations

Space powers should **kickstart the discussion** to establish an international STM organization (ISTMO) and learn from **past successes.**

The global space community should gather and grow a **cadre of experts.**

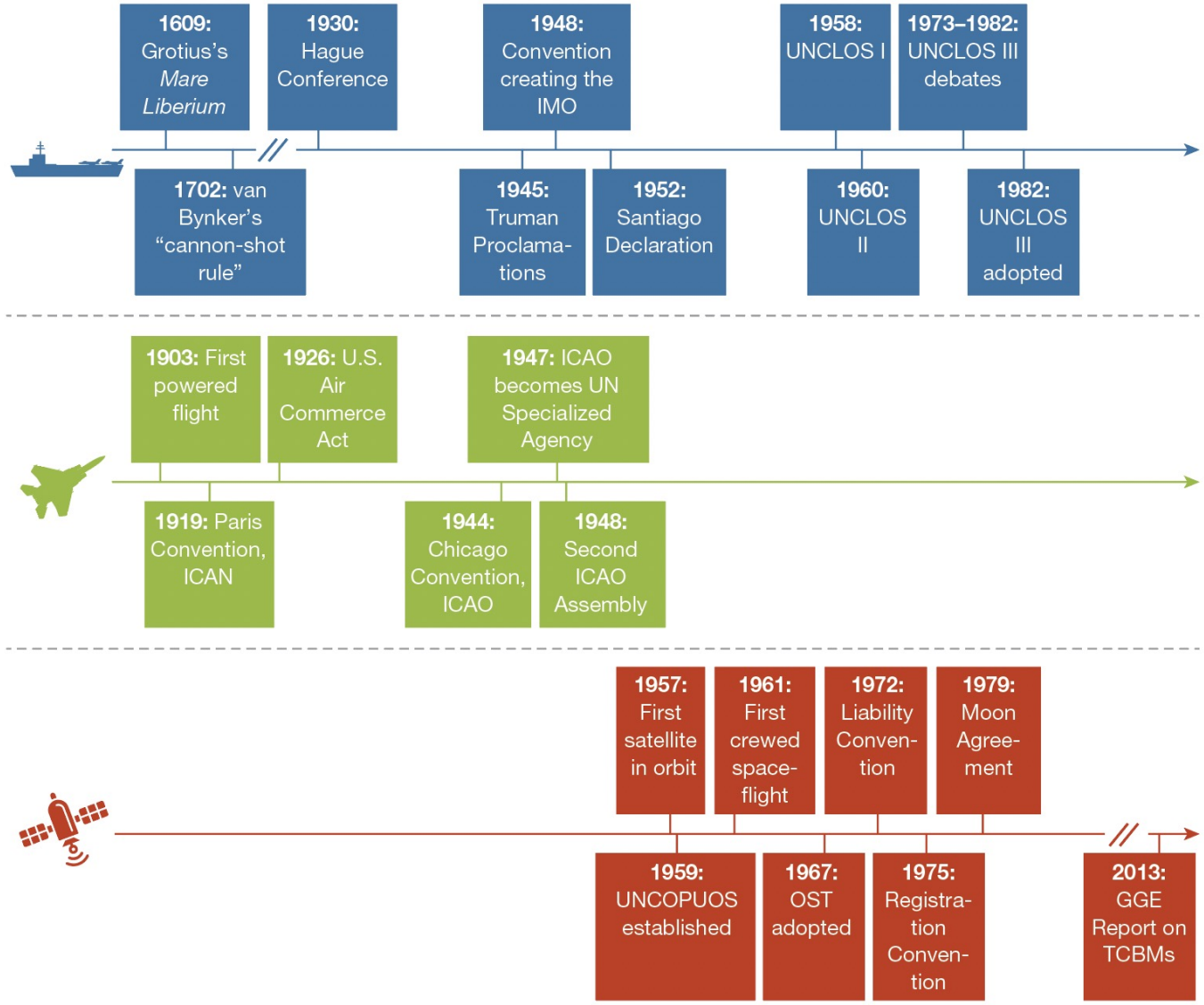
Future research should consider **alternative funding** mechanisms.

RAND Space Enterprise Initiative

> "If we do not find ways to **manage space traffic**, our past and present space activities will **jeopardize** the **safety, security and sustainability** of outer space and, as a result, our future ability to rely on space as enabler of key services in **benefit of humankind.**"
>
> – *European Commission*, An EU Approach for Space Traffic Management, *February 15, 2022*

Appendix. STM Figures

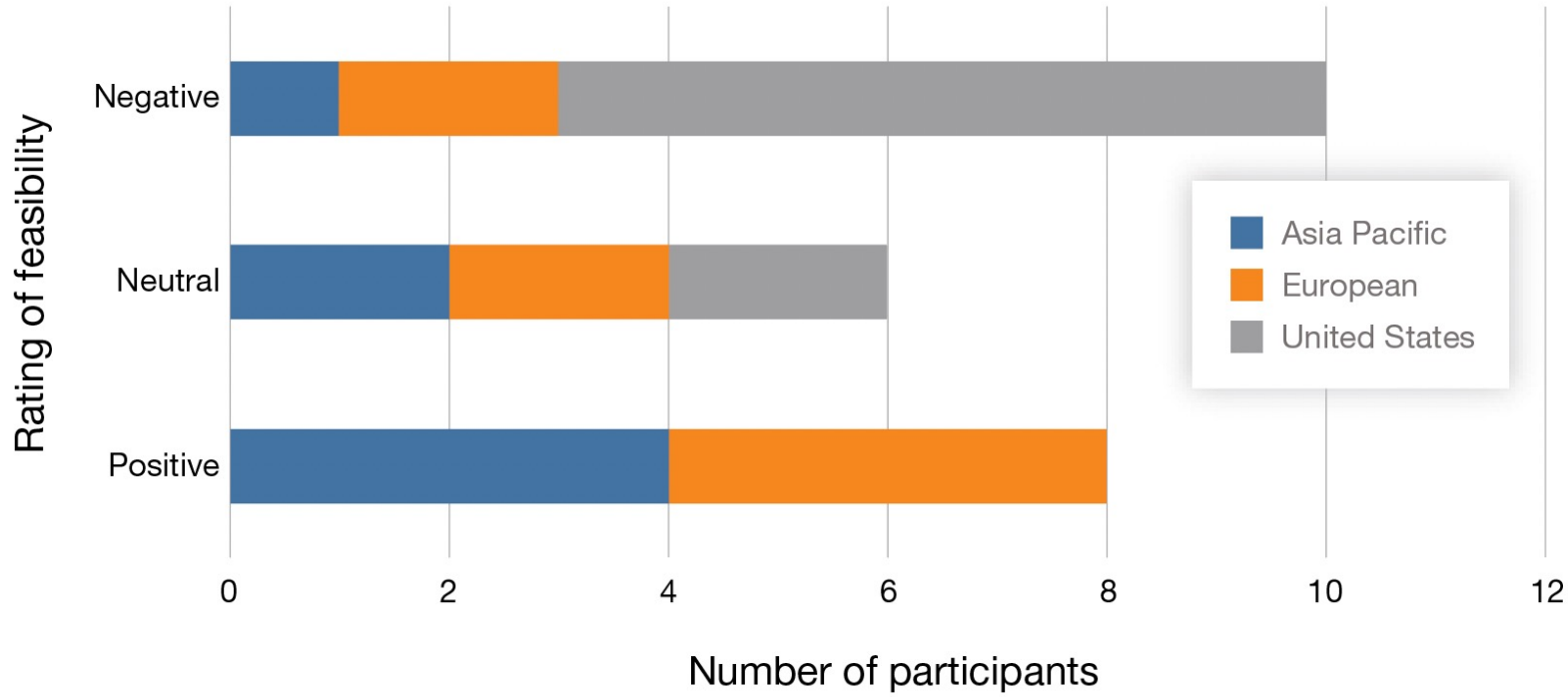
	Key Intergovernmental Organizations	Historical Challenges	Collision Environment	Solutions	Limitations	Governance Structures
Implications for Space 	• STM might emerge as UN-based entity or amalgamation of regional entities	• No formal body or mechanism to standardize space traffic procedures, prevent collisions, or resolve disputes	• Vessels vary in size (from toaster-sized to school bus–sized) and move at very high speeds (6,000 to 15,200 knots) • Debris avoidance affects fuel margins, shortening mission life	• Potential for centralized agreement with a large buy-in • Dispute resolution can be integrated with International Court of Justice (ICJ) or similar adjudicative body	• All of space faces limitations equivalent to those of the high seas or flight outside of sovereign state airspace	• Will likely require buy-in from even small states with some broad-based voting and deliberative system that includes United States, European Union, China, and Russia.
Air 	• ICAO	• Lack of standardized air traffic metrics • Lack of formal agreement to permit interstate air travel	• Vessels are generally smaller, but speed is far greater than in maritime domain (75 to 500 knots) • No lingering debris created that increases congestion • High-level human involvement	• ICAO agreement involves large buy-in to delineate common metrics and formal agreement to allow for interstate air travel	• No central investigatory body for collisions in international airspace • ICAO involvement upon request by state leading investigation	• Assembly of all states elects council that manages bureaucratic committees • Council structure represents a diversity of regions and domain interests
Maritime 	• UNCLOS • IMO • Internationally Transferred Mitigation Outcomes • ICJ	• Waters that are disputed between states • No standardized claims to water similar to those that exist for land • No standardized dispute-resolution mechanisms worldwide	• Vessels vary in size (from couch-sized to the size of five football fields) but have slower speeds (1 to 60 knots), making avoidance easier • Debris usually sinks or drifts with currents • High-level human involvement	• UNCLOS clearly delineates how sovereign waters are divided among states • ICJ, IMO, and ITMOS resolve disputes and enforce standards	• No strict enforcement or delineation on high seas as compared with near the shoreline • Regulations for automated vessels still nascent	• Assembly of all states elects council that manages bureaucratic committees • Council structure represents diversity of regions and domain interests



SOURCE: Adapted from Dan McCormick, Douglas C. Ligor, and Bruce McClintock, *Cross-Domain Lessons for Space Traffic: An Analysis of Air and Maritime Treaty Governance Mechanisms*, RAND Corporation, RR-A2208-2, 2023, p. 10.

NOTES: ICAN = International Commission for Air Navigation; UNCOPUOS = United Nations Committee on the Peaceful Uses of Outer Space; OST = Outer Space Treaty; GGE = Group of Governmental Experts; TCBM = transparency and confidence-building measure.

Workshop Participants' Ratings of Feasibility of Governance



About This Slide Deck

These slides are intended to support research that should be of interest to national and international government and military leaders and policymakers, space industry leaders and organizations, public and private interest groups and institutions involved in space, those working in academia, and all those concerned with developing formal government inputs to the issue of space traffic management. The examination of traffic coordination in other domains, as well as the recommendations resulting from an analysis of these domains, will be most useful to established and aspirant spacefaring powers and policymakers, as well as space industry participants and operators. This slide deck accompanies *International Space Traffic Management: Charting a Course for Long-Term Sustainability*, by Bruce McClintock, Douglas C. Ligor, Dan McCormick, Marissa Herron, Kotryna Jukneviciute, Thomas Van Bibber, Katie Feistel, Akhil Rao, Adi Rao, Taylor Grosso, Michael Fenner, Hanjun Lee, Abdullah Ar Rafee, and Tomás Urbina, RAND Corporation, 2023, available at www.rand.org/t/RRA1949-1. The research in that report was completed in January 2023 and underwent security review with the sponsor and the Defense Office of Prepublication and Security Review before public release.

RAND National Security Research Division

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